Apprenticeship and Industry Training

Electrical Motor Systems Technician

Apprenticeship Course Outline

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Electrical Motor Systems Technician

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Apprenticeship and Industry Training System

Apprenticeship is post-secondary education with a difference. It helps ensure Alberta has a steady supply of highly skilled employees, the foundation of our economy's future health and competitiveness.

Apprentices in more than 50 trades and crafts spend between one and four years learning their trade - 80% of the time on the job under the supervision of a certified journeyman or qualified tradesperson. The balance of the program is technical training in the theory, skills and technologies of their trade.

To become certified journeymen, apprentices must learn theory and skills, and they must pass examinations. Requirements for certification—including the content and delivery of technical training—are developed and updated by the Alberta Apprenticeship and Industry Training Board (the Board) and a network of local and provincial industry committees.

The graduate of the Electrical Motor Systems Technician apprenticeship training is a journeyman who will be able to:

- understand the principles of sound and safe trade practices.
- interpret drawings, plans, and be able to layout and develop projects according to specifications.
- use the tools of the trade in a safe and proper manner.
- relate to the work of other tradesmen employed in industry either on construction or in maintenance.
- perform assigned tasks in accordance with quality and production standards required in industry.

Apprenticeship and Industry Training Committee Industry Training Committee Structure

While government supports Alberta's apprenticeship and industry training system, it is driven by industry, a term which includes both employers and employees. The Alberta Apprenticeship and Industry Training Board, with the support of Alberta Advanced Education, oversees the system. But the system relies on a network of industry committees. These committees include local and provincial apprenticeship committees (LACs and PACs) in the designated trades and occupational committees (OCs) in the designated occupations, as well as other committees such as provisional committees established before the designation of a new trade or occupation comes into effect. All these committees are composed of equal numbers of employers and employees. The network of industry committees is the foundation of Alberta's apprenticeship and industry training system.

Local Apprenticeship Committees (LAC)

Wherever there is activity in a trade, the Board can set up a LAC. The Board appoints equal numbers of employees and employers for terms of up to three years. The committee appoints a member as presiding officer. Local Apprenticeship Committees:

- monitor the apprenticeship system, and the progress of apprentices in their trade, at the local level.
- help settle certain kinds of issues between apprentices and their employers.
- recommend improvements in apprenticeship training and certification to their trade's provincial apprenticeship committee.
- make recommendations to the Board regarding the appointment of members to their trade's PAC.

Provincial Apprenticeship Committees (PAC)

The Board establishes a PAC for each trade and, based on PAC recommendations, appoints a presiding officer and equal numbers of employees and employers for terms of up to three years. Most PACs have nine members. Provincial Apprenticeship Committees:

- identify the training needs and content for their trade.
- recommend to the Board the standards for training and certification for their trade.
- monitor the activities of local apprenticeship committees in their trade.
- make recommendations to the Board about the designation of trades and occupations.
- determine whether training of various kinds is equivalent to training provided in an apprenticeship program in the trade.
- may participate in resolving any apprenticeship-related disputes between employers and employees.

Electrical Motor Systems Technician PAC Members

Mr. D. Graham	Lethbridge	Presiding Officer
Mr. J. McDonald	Calgary	Employer
Mr. L. Deroche	Edmonton	Employer
Mr. E. Sandboe	Grande Prairie	Employer
Mr. T. Brolund	Calgary	Employee
Mr. M. Graham	Lethbridge	Employee
Mr. R. Laversin	Edmonton	Employee
Mr. C. MacDonald	Edmonton	Employee

The Alberta Apprenticeship and Industry Training Board (Board)

The mandate of the Alberta Apprenticeship and Industry Training Board relates to the standards and requirements for training and certification in programs under the *Apprenticeship and Industry Training Act*. The Board provides advice to the Minister of Advanced Education on the training and certification of people in designated trades and occupations and on the needs of the Alberta labour market for skilled and trained persons. The Board also makes orders and regulations respecting standards and requirements for apprenticeship programs and the training of apprentices and for training and certification in designated trades and occupations, and the criteria or requirements for granting and recognizing trade and other certificates.

The 13-member Board consists of a chair, eight members representing trades and four members representing other industries. Employer and employee representatives equally represent the trades and other industry members.

Safety Education

Safe working procedures and conditions, accident prevention and the preservation of health are of primary importance in apprenticeship programs in Alberta. These responsibilities are shared and require the joint efforts of government, employers, employees and the public. Therefore, it is imperative that all parties become aware of circumstances that may lead to injury or harm. Safe learning experiences and environments can be created by controlling the variables and behaviours that may contribute to or cause an accident or injury.

It is generally recognized that a safe attitude contributes to an accident free environment. Everyone will benefit as a result of a healthy, safe attitude towards prevention of accidents.

A tradesperson is possibly exposed to more hazards than any other person in the work force and, therefore, should be familiar with and apply the Occupational Health and Safety Act and Regulations dealing with personal safety and the special safety rules applying to each task.

Legal and Administrative Aspects of Safety

Accident prevention and the provisions of safe working conditions are the responsibilities of an employer and employee.

Employer's Responsibilities

The employer is responsible for:

- providing and maintaining safety equipment and protective devices.
- ensuring proper safe work clothing is worn.
- enforcing safe working procedures.
- providing safeguards for machinery, equipment and tools.
- observing all accident prevention regulations.
- training employees in the safe use and operation of equipment.

Employee's Responsibilities

The employee is responsible for:

- working in accordance with the safety regulations pertaining to the job environment.
- working in such a way as not to endanger themselves or fellow employees.

Occupational Health and Safety's Responsibilities:

Occupational Health and Safety (Alberta Human Resources and Employment) will conduct periodic inspections of the workplace to ensure that safety regulations for industry are being observed.

Technical Training Establishment

Alberta Advanced Education, Apprenticeship and Industry Training offer your apprenticeship training program. Staff and facilities for delivering the program are supplied by the Southern Alberta Institute of Technology (main campus)

Procedures for Recommending
Revisions to the Course Outline

Apprenticeship and Industry Training, Industry Programs and Standards has prepared this course outline in partnership with the Electrical Motor Systems Technician Provincial Apprenticeship Committee.

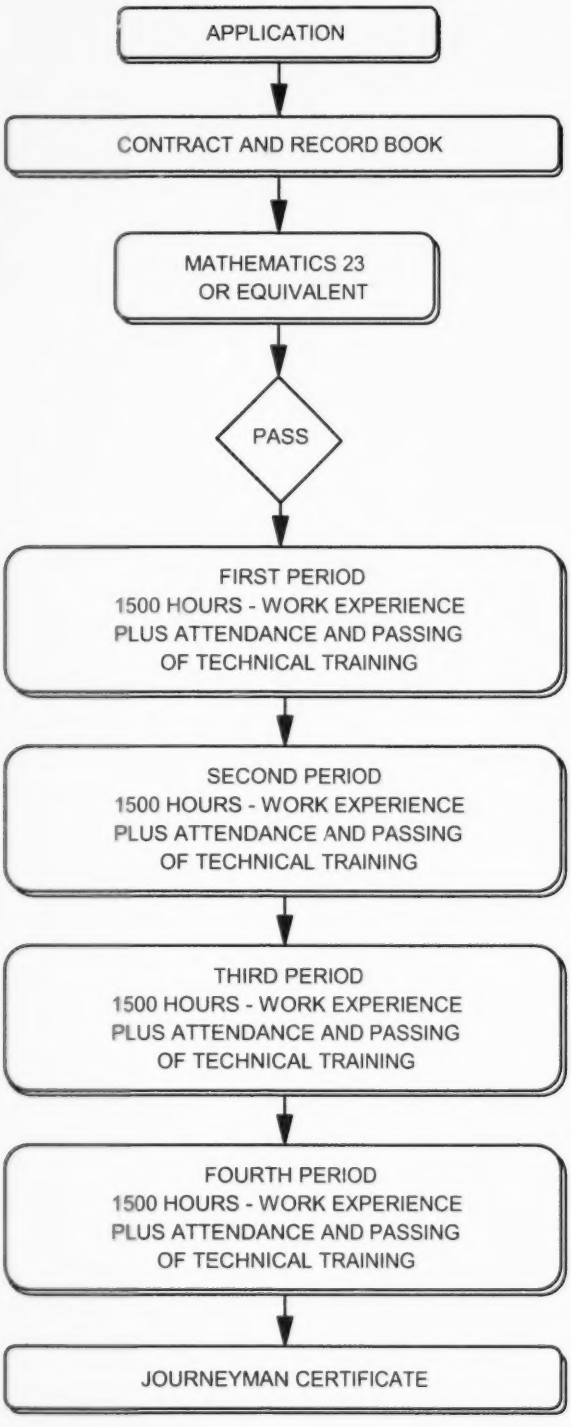
This course outline was approved on May 5, 2006 under the authority of the Alberta Apprenticeship and Industry Training Board on a recommendation from the Provincial Apprenticeship Committee. Valuable input is acknowledged from industry and the institutions.

Any concerned citizen or group in the Province of Alberta may make recommendations for change by writing to:

Electrical Motor Systems Technician Provincial Apprenticeship Committee
c/o Industry Programs and Standards
Apprenticeship and Industry Training
10th floor, Commerce Place
10155 - 102 Street
Edmonton, AB T5J 4L5

It is requested that recommendations for change refer to specific areas and state references used. Recommendations received will be placed before regular meetings of the Provincial Apprenticeship Committee.

Apprenticeship Route toward Certification



Electrical Motor Systems Technician Training Profile

FIRST PERIOD
(8 Weeks 30 Hours per Week – Total of 240 Hours)

SECTION ONE

ELECTRICAL THEORY — **122 Hours**

- **A** — Mathematics — 12 Hours
- **B** — Principles of Electricity — 110 Hours

SECTION TWO

DC MACHINES — **44 Hours**

- **A** — Principles of Operation — 30 Hours
- **B** — Repair and Rewinding — 14 Hours

SECTION THREE

REPAIR AND INSTALLATION OF MACHINE COMPONENTS — **36 Hours**

- **A** — Tools of the Trade — 4 Hours
- **B** — Gas Welding and Cutting — 6 Hours
- **C** — Practical Applications of Gas Welding and Cutting — 10 Hours
- **D** — Equipment Repair and Installation — 16 Hours

SECTION FOUR

CIRCUIT CONTROLS — **26 Hours**

- **A** — Switches — 6 Hours
- **B** — Relays — 4 Hours
- **C** — Schematics and Wiring Diagrams — 16 Hours

SECTION FIVE

SAFETY AND REGULATIONS — **12 Hours**

- **A** — Occupational Health and Safety — 1 Hour
- **B** — Workers' Compensation Act — 1 Hour
- **C** — Electrical Motor Systems Technician Apprenticeship Training Program Orientation — 2 Hours
- **D** — Shop Safety — 4 Hours
- **E** — Rigging and Hoisting — 4 Hours

SECOND PERIOD

(8 Weeks 30 Hours per Week – Total of 240 Hours)

SECTION ONE

ELECTRICAL THEORY
100 Hours

⇨

A
Principles of Electricity 100 Hours

SECTION TWO

REPAIR AND REWINDING
66 Hours

⇨

A	B	C
Operation of Metal Lathe 16 Hours	DC Armatures 25 Hours	Single Phase Induction Motors 25 Hours

SECTION THREE

SINGLE PHASE MOTORS
30 Hours

⇨

A
Principle of Operation 30 Hours

SECTION FOUR

MAGNETIC SWITCHING AND CONTROL CIRCUITS
32 Hours

⇨

A	B	C
Relays and Magnetic Starters 9 Hours	Control Circuit Devices 4 Hours	Circuits and Connections 14 Hours

D
Overload Protection 5 Hours

SECTION FIVE

SAFETY AND REGULATIONS
12 Hours

⇨

A
Canadian Electrical Code Part 1 12 Hours

THIRD PERIOD

(8 Weeks 30 Hours per Week – Total of 240 Hours)

SECTION ONE

ELECTRICAL THEORY
92 Hours

⇨

A	B
Three-Phase Motors 68 Hours	Principles of Electricity 24 Hours

SECTION TWO

MOTOR REWINDING
110 Hours

⇨

A	B	C
Motor Winding Theory 60 Hours	Motors Winding Lab 40 Hours	Rotors Lab 10 Hours

SECTION THREE

TRANSFORMERS
36 Hours

⇨

A	B
Theory of Operation 14 Hours	Connections for Single Phase and Three Phase Transformers 22 Hours

SECTION FOUR

SAFETY AND REGULATIONS
2 Hours

⇨

A
Canadian Electrical Code Part 1 2 Hours

FOURTH PERIOD
(8 Weeks 30 Hours per Week – Total of 240 Hours)

SECTION ONE

TRADE APPLICATIONS
50 Hours

A	B	C
Explosion—Proof Motors 12 Hours	DC Armatures 6 Hours	Phase Converters 8 Hours
D	**E**	**F**
Troubleshooting Rotating Electrical Equipment 4 Hours	Vibration Analysis 12 Hours	Balancing 8 Hours

SECTION TWO

THREE PHASE MOTOR STARTERS & CONTROLLERS
50 Hours

A	B	C
Starters 30 Hours	Controllers 10 Hours	Adjustable Speed Drives 10 Hours

SECTION THREE

SYNCHRONOUS MACHINES
44 Hours

A	B
Motors 22 Hours	Alternators 22 Hours

SECTION FOUR

ELECTRONICS / DIODES / RECTIFIERS
40 Hours

A	B	C
Electrical Properties and Measuring Instruments 18 Hours	Diodes and Rectifier Circuits 12 Hours	Applications of Diodes and Rectifiers 10 Hours

SECTION FIVE

ELECTRONICS / POWER / SWITCHING
32 Hours

A	B	C
Transistors and Photo Devices 12 Hours	Thyristors 10 Hours	Practical Applications of Thyristor Circuits 10 Hours

SECTION SIX

ELECTRONICS APPLICATIONS
4 Hours

A
Voltage Regulators 4 Hours

SECTION SEVEN

ELECTRIC WELDING EQUIPMENT
4 Hours

A
Trouble Shooting Electric Welders 4 Hours

SECTION EIGHT

PROGRAMMABLE LOGIC CONTROLLERS
16 Hours

A	B
Theory of Operation 4 Hours	Practical Applications 12 Hours

NOTE: The hours stated are for guidance and should be adhered to as closely as possible. However, adjustments must be made for rate of apprentice learning, statutory holidays, registration and examinations for the training establishment and Apprenticeship and Industry Training

FIRST PERIOD TECHNICAL TRAINING
ELECTRICAL MOTOR SYSTEMS TECHNICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM, THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: ..... ELECTRICAL THEORY ..... 122 HOURS

A. Mathematics ..... 12 Hours

Outcome: Solve trade-related problems using basic mathematical skills.

1. Display the ability to do addition, subtraction, multiplication and division (with or without calculators) of:
   a) whole numbers
   b) decimals
   c) fractions
   d) signed numbers
   e) exponents
2. Solve problems involving square root.
3. Solve problems involving percentages.
4. Transpose simple algebraic equations.
5. Solve right angle triangles using trigonometric functions given unknowns.
6. Solve phasor (vector) problems involving magnitude and directions.
7. Explain the usage of reciprocals in electrical problems.
8. Display the ability to interpret information from graphs.
9. Demonstrate plotting principles.
10. Solve problems using SI systems for:
    a) linear
    b) area
    c) volume
    d) weight
    e) temperature

B. Principles of Electricity ..... 110 Hours

Outcome: Understand the electrical characteristics of AC and DC circuits.

1. Explain the fundamental relationship between the structure of the atom and flow of electrons.
2. Describe electron theory.
3. Describe the methods used to generate AC and DC.
4. Describe the relationship between cycles, poles and frequency.
5. Define quantity, express symbols and units of measurement for the units of measurement for the following electrical terms:
   a) Volts
   b) amperes
   c) Ohms
   d) Watts
   e) Watt-hours

f) coulombs
g) joules

6. Describe the relationship of voltage, current and resistance in an electric circuit.
7. Solve problems using Ohm's law.
8. Connect circuits and make voltage, current and resistance measurements to verify Ohm's law.
9. Describe electrical circuits
   a) series
   b) parallel
   c) three wire Edison circuit
      i) balanced
      ii) unbalanced
      iii) open neutral
10. Analyse and explain series, parallel and Edison three wire circuits and identify their applications.
11. Describe and apply Kirchoff's voltage law to circuits for series, parallel and three wire circuits.
12. Describe and apply Kirchoff's current law to circuits for series, parallel and three wire circuits.
13. Define and calculate line drop, line loss and efficiency in electrical circuits.
14. Solve problems involving series, parallel and Edison three wire circuits (balanced and unbalanced).
15. Define and calculate line drop, line loss and efficiency of a simple motor-generator feeder system.
16. Connect and take measurements of series and parallel circuits using schematic and wiring diagrams to verify Ohm's law.
17. Define the characteristics of copper and aluminum conductors with reference to electricity.
18. Define resistivity of conductors.
19. Describe wire sizes using AWG or SI.
20. Calculate temperature coefficient of resistance.
21. Define insulators with reference to electricity.
22. Define semi-conductors with reference to electricity.
23. Define work, energy and power.
24. State the units of work, energy and power.
25. Calculate electrical power.
26. Calculate mechanical power and work.
27. Convert horsepower to watts.
28. Define torque.
29. Calculate measurement of torque (Prony Brake).
30. Describe the production of a sine wave in an alternating current source.
31. Define instantaneous value.
32. Define RMS or effective value.
33. Define maximum or peak value.
34. Define and draw phasors to represent electrical characteristics of loads in an AC system.
35. Define:
   a) vector
   b) phase
   c) lead
   d) lag

e) cycle
f) angles in electrical degrees

36. Describe the characteristics of magnetic lines of force.
37. Describe the laws of magnetic attraction and repulsion.
38. Describe the field around a current carrying conductor.
39. Describe electromagnetic induction
40. Describe the electromagnetism.
41. Explain Faraday's law of induction.
42. Explain Lenz's law of induction.
43. Explain Fleming's hand rule for generator action.
44. Explain the losses that occur in an AC electromagnet.
45. Describe self-induction in a coil.
46. Describe the relationship between current and magnetism to explain transformer action.
47. Explain the Galvanometer and the principle of meter movements.
    a) Describe the proper use and precautions for meters:
    b) ammeters
    c) voltmeters
    d) ohmmeters
    e) meggers
    f) wattmeters
    g) multimeters
    h) high potential insulation testing
48. Demonstrate proper scale range selection and wiring connections.
49. Demonstrate accurate measurements.
50. Calculation of meters for AC and DC measurements.
51. Calculate using correct shunts or multipliers.
52. Describe the purpose and safe use of a growler.
53. Explain the use a growler to test for shorts, opens and ground faults.
54. Differentiate between an inside growler and outside growler.

SECTION TWO: ..... DC MACHINES ..... 44 HOURS

A. Principles of Operation ..... 30 Hours

Outcome: Understand the fundamental components and operation of DC machines.

1. Name the parts of the magnetic circuit of a DC machine including:
    a) field yoke
    b) pole cores
    c) armature core
    d) end bells
    e) air gaps
2. List and explain the following pieces of information found on a DC motor and generator's nameplate including:
    a) rpm
    b) volts (armature and field)
    c) output
        i) kW

ii) hp
d) current (armature and field)
e) temperature rise

3. Name and explain the application of the parts of the electrical circuit of a DC machine including:
   a) armature winding
   b) commutator
   c) brushes
   d) field windings
   e) interpoles and compensating poles
   f) brush holders

4. Explain the characteristics and demonstrate the different methods of field excitation including:
   a) separate
   b) series
   c) shunt
   d) compound

5. Explain the principles and characteristics of voltage regulation of a DC generator.

6. Calculate the efficiency of a DC generator.

7. Explain how torque is produced in a DC motor.

8. Explain and demonstrate the methods of starting DC motors.

9. Explain and demonstrate the methods of speed control of DC motors.

10. Explain the principles and characteristics that affect speed regulation of DC motors.

11. Describe dynamic braking of a DC motor.

12. Explain and draw connections of various DC motors.

13. Describe methods to reverse direction of various DC motors.

14. Connect various DC motors.

15. Apply methods of troubleshooting DC machines.

B. Repair and Rewinding.....14 Hours

Outcome: Understand the practical application of winding a DC field coil.

1. Describe the types of insulation used.

2. Explain the different classes and uses of insulation.

3. Record field coil measurements.

4. Record field coil winding data.

5. Demonstrate the construction of a DC field coil form.

6. Demonstrate winding, shaping and taping of a DC field coil.

7. Test for continuity and resistance of the winding.

8. Test for insulation resistance.

9. Explain the purpose of dipping and baking a DC field coil.

SECTION THREE: .....REPAIR AND INSTALLATION OF MACHINE COMPONENTS .....36 HOURS

A. Tools of the Trade .....4 Hours

Outcome: Identify and understand the safe use and care of tools related to the trade.

1. Identify and describe the correct and safe use of hand tools related to this trade.
2. Identify and describe the correct and safe use of measuring tools for various applications.
3. Demonstrate the correct care and maintenance of all hand tools.
4. Identify and describe the correct and safe use of power tools:
5. Demonstrate the correct procedures for:
   a) dressing and truing grinding wheels
   b) grinding lathe tools
   c) grinding twist drills
   d) dressing chisels, screwdrivers, etc.
6. Describe the proper types and uses of grinding wheels.
7. Explain the correct storage of grinding wheels.
8. Demonstrate the safe use of power tools.

B. Gas Welding and Cutting (as a Tool of the Trade) .....6 Hours

Outcome: Understand the components and uses of gas welding and cutting equipment.

1. Explain the characteristics of oxygen and fuel gases.
2. Describe the handling procedures for oxygen and fuel gases.
3. Recognise the construction and function of regulators and hoses.
4. Describe the use, care and maintenance of oxy-fuel equipment components.
5. Select the attachments required for cutting and know the required safety precautions to be taken.
6. Explain the use of personal protective equipment required.
7. Explain the recommended procedure for placement, set-up and shutting down the equipment.
8. Identify causes and preventive measures for backfires, flashbacks and burn backs.
9. Describe pressure and flame adjustments.

C. Practical Applications of Gas Welding and Cutting (as a Tool of the Trade).....10 Hours

Outcome: Safe and effective use of gas welding and cutting equipment.

1. Demonstrate safe operating techniques of gas welding and cutting equipment.
2. Demonstrate the ability to safely operate a hand-held oxy-fuel cutting torch on available plate and structural shapes.
3. Perform straight line and bevel cutting on available mild steel.
4. Demonstrate the ability to cut off bearings from equipment shafts.
5. Demonstrate the ability to cut off equipment components.
6. Demonstrate the ability to safely heat equipment components for removal or assembly.
7. Demonstrate the ability to braze and solder components.

D. Equipment Repair and Installation ..... 16 Hours

Outcome: Identify and understand proper mechanical procedures for repair of equipment.

1. Describe the types and uses of friction and anti-friction bearings.
2. Demonstrate the various methods of bearing removal.
3. Check shafts before bearing installation.
4. Describe the installation procedures of various bearings.
5. Describe the different types and installation of gaskets and seals including:
   a) O rings
   b) U section rings
   c) V packing
   d) cup packing
   e) piston ring
   f) lip seal
   g) mechanical seals
   h) floating seal
6. Describe and demonstrate the general alignment of motors with other equipment including:
   a) flat belt
   b) v-belt
   c) direct couple
7. Calculate speeds using:
   a) belts
   b) pulleys
   c) gears

SECTION FOUR: ..... CIRCUIT CONTROLS ..... 26 HOURS

A. Switches ..... 6 Hours

Outcome: Describe specific circuit switching arrangements by creating schematic drawing and wiring diagrams and demonstrating their connections in a lab.

1. Draw schematics and demonstrate connections for:
   a) single and multiple pole switches
   b) single and multiple throw switches
   c) multi-position switch
   d) rotary switches
   e) push button switches
   f) three-way switches
   g) four-way switches
   h) limit switches

B. Relays ..... 4 Hours

Outcome: Analyze and connect control circuits that use relays.

1. Identify the parts of a relay.
2. Describe the operating principle of a relay.
3. Demonstrate the connection of circuits using relays.

C. Schematics and Wiring Diagrams.....16 Hours

Outcome: ***Interpret circuit diagrams of simple electrical installations and demonstrate the ability to connect the same.***

1. Define specific terms that are used when referring to control circuits.
2. Draw the symbols that are commonly used in control circuits.
3. Differentiate between schematics and wiring diagrams.
4. Simplify wiring diagrams to schematic representations.
5. Draw schematic and wiring diagrams for various circuits.
6. Connect relays for various circuits.

SECTION FIVE: .....SAFETY AND REGULATIONS .....12 HOURS

A. Occupational Health and Safety.....1 Hour

Outcome: ***Demonstrate knowledge of safe work practices, safety procedures and responsibility for safety in the workplace.***

1. Demonstrate an ability to locate and interpret major sections of the Occupational Health and Safety (OHS) Act.
2. Demo nstrate an ability to locate and interpret sections of the General Safety Regulations.
3. Demonstrate an ability to locate and interpret Serious Injury Accident, Noise and First Aid Regulations.

B. Workers Compensation Act .....1 Hour

Outcome: ***Become familiar with the Workers Compensation Act.***

1. Define the principle of Workers Compensation Act.

C. Electrical Motor Systems Technician Apprenticeship Training Program Orientation .....2 Hours

Outcome: ***Understand the role of the tradesmen, employers, Local Apprenticeship Committees, the Provincial Apprenticeship Committee and Alberta Apprenticeship and Industry Training in the development and maintenance of the electric motor systems technician trade in Alberta.***

1. Describe the apprenticeship training system in Alberta.
2. Study the training profile of the electric motor systems technician apprenticeship in Alberta.
3. Describe the electric motor systems technician program outline learning outcomes and objectives.
4. Describe the responsibilities for the Contract of Apprenticeship by the apprentice, employer and Alberta Apprenticeship and Industry Training.
5. Describe a variety of employment opportunities for electric motor systems technician.
6. Become familiar with the contents of the apprenticeship training Record Book.

D. Shop Safety.....4 Hours

Outcome: ***Demonstrate the knowledge of safe workplace practices.***

1. Demonstrate the safe use of tools and equipment.
2. Demonstrate the proper use of personal protective equipment.

3. Describe various hazards of the trade and measures to safeguard against them.

E. Rigging and Hoisting ..... 4 Hours

Outcome: Demonstrate the ability to safely lift equipment.

1. Describe safety procedures in hoisting.
2. Describe basic OHS hand signals for hoisting.
3. Identify types of slings, their load capabilities and applications.
4. Describe the effect that sling angles have in safe lifting including:
   a) critical angle of slings
   b) load limits
   c) shock loading
5. Identify the mechanical advantages of single and multiple sheave rigging configurations.

SECOND PERIOD TECHNICAL TRAINING
ELECTRICAL MOTOR SYSTEMS TECHNICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: .....ELECTRICAL THEORY.....100 HOURS

A. Principles of Electricity..... 100 Hours

Outcome: Understand the electrical characteristics of AC circuits.

1. Explain alternating current as it pertains to sine waves and phasors.
2. Explain instantaneous value of a sine wave.
3. Explain RMS or effective value of a sine wave.
4. Explain maximum or peak value of a sine wave.
5. Define and draw phasors to represent electrical characteristics of loads in an AC system.
6. Define:
   a) phasors (vectors)
   b) phase
   c) lead
   d) lag
   e) cycle
   f) angles in degrees
      i) electrical
      ii) mechanical
7. Define inductance and state its symbol.
8. State the unit of measurement for inductance and its symbol.
9. Describe inductance and the factors which affect inductance.
10. Describe the effects of inductance.
11. Describe the DC inductive effects.
12. Describe the AC inductive effects.
13. Define inductive reactance and state its symbol.
14. State the unit of measurement for inductive reactance and its symbol.
15. Calculate the total inductance when inductors are connected in series or parallel.
16. State Faraday's law.
17. State Lenz's law.
18. Solve problems involving series and parallel circuits with resistance and inductance.
19. Describe the construction and characteristics of an elementary capacitor.
20. Describe capacitance and the factors that affect it.
21. Describe capacitor types and applications.
22. Explain AC capacitive effects.
23. State the unit of measurement for the charge of a capacitor and give its symbol.

24. Define dielectric strength.
25. Define capacitance.
26. State the unit measurement for capacitance.
27. Define capacitive reactance.
28. Describe the symbol for capacitive reactance and state its unit of measurement.
29. Explain the equation for capacitive reactance.
30. State the phase relationship between voltage and current in a capacitive circuit.
31. Calculate the total capacitance of capacitors in series or parallel.
32. Calculate the capacitive reactance of any given circuit.
33. Solve problems involving series and parallel circuits with resistance and capacitance.
34. Calculate the value of a time constant for an RC circuit.
35. Solve problems involving resonance.
36. Define impedance in single-phase circuits.
37. State the unit of measure for impedance.
38. State the components of an impedance triangle.
39. Calculate for the components of an impedance triangle.
40. Define power and give its symbol.
41. State the unit of measurement of power and give its symbol and unit of measurement.
42. Define apparent power and give its symbol.
43. State the unit of measurement for apparent power and give its symbol and unit of measurement.
44. Define reactive power and give its symbol.
45. State the unit of measurement for reactive power and give its symbol and unit of measurement.
46. Define power factor.
47. Define phase angle and give its symbol.
48. Calculate:
    a) impedance
    b) current
    c) voltage
    d) voltage drops
    e) apparent power
    f) total power
    g) power factor
    h) power factor correction
49. Draw phasor diagrams for multiple loads.
50. Explain the generation of three phase voltages.
51. State the advantages for three phase systems over single-phase systems.
52. Name the types of three phase connections.
53. Define the term balanced three phase systems.
54. State the phase relationship for the 3 voltages in a three-phase system.
55. State and demonstrate by phasor analysis the relationship between Ephase and Eline for a wye system.
56. State and demonstrate by phasor analysis the relationship between Ephase and Eline for a delta system.

57. State and demonstrate by phasor analysis the relationship between Iphase and Iline for a wye system.
58. State and demonstrate by phasor analysis the relationship between Iphase and Iline for a balanced delta system.

SECTION TWO: ..... REPAIR AND REWINDING ..... 66 HOURS

A. Operation of a metal lathe ..... 16 Hours

Outcome: Demonstrate the ability to safely operate a metal lathe.

1. Identify and describe the correct use and maintenance of a metal lathe.
2. Describe the correct safety protection required when using a lathe.
3. Identify the proper cutting tools for various materials.
4. Demonstrate tool sharpening techniques.
5. Identify and select cutting speeds for various materials.
6. Demonstrate centre drilling on a lathe.
7. Demonstrate chucking and dialling in the armature on a lathe.
8. Demonstrate turning a commutator on a lathe.

B. DC Armatures ..... 25 Hours

Outcome: Demonstrate the correct procedures for rewinding a DC armature.

1. Demonstrate stripping.
2. Demonstrate the ability to record data.
3. Demonstrate insulating.
4. Demonstrate rewinding.
5. Demonstrate the turning and under-cutting of a commutator.
6. Demonstrate the ability to test an armature for faults.
7. Demonstrate armature banding.
8. Demonstrate the proper technique of using soldering irons or torches.
9. Demonstrate the proper technique of silver brazing.

C. Single Phase Induction Motors ..... 25 Hours

Outcome: Demonstrate the correct procedures for trouble shooting, rewinding and repairing single-phase induction motors.

1. Demonstrate stripping.
2. Demonstrate the ability to record data.
3. Demonstrate different winding methods.
4. Draw proper radial and schematic diagrams.
5. Demonstrate the ability to test for electrical and mechanical faults.
6. Dismantle and identify all parts.
7. Clean and insulate all slots.

8. Wind and replace all coils.
9. Connect and secure all coils.
10. Explain the method of dipping and baking and demonstrate reassembly.
11. Find faults and replace starting switches, centrifugal mechanisms, capacitors and built-in devices.
12. Demonstrate the ability to make proper winding connection.
13. State the temperature ratings and classes of insulation.

SECTION THREE: ..... SINGLE PHASE MOTORS ..... 30 HOURS

A. Principle of Operation ..... 30 Hours

Outcome: Understand the characteristics and application of AC single phase motors.

1. Explain the principles, characteristics and applications of series (universal) single-phase motors.
2. Explain the principles, characteristics and applications of split phase single-phase motors.
3. Explain the principles, characteristics and applications of capacitor single-phase motors.
   a) capacitor start
   b) permanent-split-capacitor
   c) capacitor start / capacitor run
4. Explain the principles, characteristics and applications of shaded pole single-phase motors.
5. Demonstrate connections, draw diagrams and perform lead identification for series (universal) motors.
6. Demonstrate connections, draw diagrams and perform lead identification for split phase motors.
7. Demonstrate connections, draw diagrams and perform lead identification for capacitor motors.
   a) capacitor start
   b) permanent-split-capacitor
   c) capacitor start / capacitor run
8. Demonstrate connections, draw diagrams and perform lead identification for shaded pole motors.
9. Draw connection diagrams for single and dual voltage motors.
10. Draw connection diagrams for multiple speed, two speed and instant reversing motors.
11. Draw connection diagrams for current and voltage starting relays and electronic start switches.
12. Explain protective devices including:
    a) built in thermal
    b) overload relays
13. Explain the operation and application of built-in thermal overload devices for single and dual voltage motors.
14. Demonstrate the installation and adjustment of centrifugal mechanisms and starting switches.
15. Demonstrate the installation of solid state, current and potential relays as starting switches for replacement for centrifugally operated types.
16. Explain nameplate information.
17. Determine the speed of magnetic field as compared to the rotor speed:

SECTION FOUR: ..... MAGNETIC SWITCHING AND CONTROL CIRCUITS ..... 32 HOURS

A. Relays and Magnetic Starters ..... 9 Hours

Outcome: Understand the characteristics of relays versus magnetic starters and their proper applications.

1. Explain the construction of relays as compared to magnetic contactors or starters.
2. Explain the use of various relays:
   a) single contact
   b) multi-contact
   c) enclosed and open contact
   d) plug in bases
   e) latching mechanical reset
   f) latching electrical reset
3. Explain the operation of relays compared to magnetic contactors or starters.
4. Explain the application of relays compared to magnetic contactors.
5. Describe the operation of the components of a magnetic motor starter.
6. Demonstrate the ability to troubleshoot and perform maintenance on magnetic motor starters.
7. Differentiate between low voltage release and low voltage protection.

B. Control Circuit Devices..... 4 Hours

Outcome: Understand the types and uses of control circuit devices.

1. Explain the difference between momentary and maintained contact switches.
2. Draw a push button start-stop station as it applies to low voltage protection.
3. Explain the various types of switches used in motor control including:
   a) float switches
   b) pressure switches
   c) limit switches
4. Describe the application of indicator lights.
5. Explain the application of holding and auxiliary contacts .

C. Circuits and Connections..... 14 Hours

Outcome: Demonstrate the use of control and power circuits in relation to motor starting methods.

1. Demonstrate the use of control and power circuits for start-stop stations.
2. Demonstrate the use of control and power circuits for start-jog-stop stations.
3. Demonstrate the use of control and power circuits for forward–reverse-stop stations.
4. Describe the applications and operations of electrical interlocking.
5. Describe the application and operation of mechanical interlocking.
6. Develop schematic and wiring diagrams of across the line and forward-reversing starters.
7. Interpret shop drawings, circuit diagrams and ladder logic.

D. Overload Protection ..... **5 Hours**

Outcome: ***Understand the various types of and operation of overload protection devices.***

1. Describe the make up and operation of thermal overload relays.
2. Explain the operation of magnetic overload relays.
3. Explain the operation of electronic overload devices.
4. Explain the operation of thermal devices:
   a) thermistor
   b) RTD
   c) klixon
   d) thermocouples
5. Describe and understand I.E.C. and EEMAC ratings.

SECTION FIVE: ..... **SAFETY AND REGULATIONS** ..... **12 HOURS**

A. Canadian Electrical Code Part 1 ..... **12 Hours**

Outcome: ***Understand why and how the Canadian Electrical Code (CEC) Part I is used to provide minimum standards as they apply in the trade.***

1. Find information within the CEC Part I and know who is responsible for electrical installations.
2. Interpret safety standards provided in the CEC from section 0.
3. Interpret safety standards provided in the CEC from section 10.
4. Interpret safety standards provided in the CEC from section 28.

THIRD PERIOD TECHNICAL TRAINING
ELECTRICAL MOTOR SYSTEMS TECHNICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: .....ELECTRICAL THEORY.....92 HOURS

A. Three-Phase Motors.....68 Hours

Outcome: ***Understand the various types, major components and principles of operation of three-phase motors.***

1. Describe the main types of three phase motors.
2. Describe the make-up and function of the stator of the squirrel cage induction motor.
3. Describe the make-up and function of the rotor of the squirrel cage induction motor.
4. Describe the make-up and function of the end bells and bearings of the squirrel cage induction motor.
5. Describe the methods of cooling the squirrel cage induction motor.
6. Explain nameplate information
7. Explain the principle of operation of induction motors.
8. Determine the speed of a rotating magnetic field.
9. Explain and determine rotor frequency, slip, poles and RPM relationship.
10. Explain percent speed regulation.
11. Explain factors of motor efficiency.
12. Calculate currents, voltages, power, power factor and efficiency of induction motors.
13. Draw EEMAC numbered schematic diagrams of dual voltage motors.
14. Demonstrate the ability to properly identify unmarked external motor leads for 9 lead dual voltage wye-connected motors.
15. Demonstrate the ability to properly identify unmarked external motor leads for 9 lead dual voltage delta-connected motors.
16. Demonstrate the ability to properly identify unmarked external motor leads for 6 lead wye-delta motors.
17. Demonstrate the ability to properly identify unmarked external motor leads for two speed consequent pole motors.
18. Describe the development of consequent poles in the stator.
19. Describe the principal of operation of a single winding two-speed consequent pole motor.
20. Describe the principal of operation of a dual winding two-speed motor.
21. Identify the type of two-speed motor based upon the nameplate data.
22. Draw connection diagrams for low and high speeds of two-speed motors.
23. Draw the EEMAC numbered schematics for two-winding and consequent pole motors.
24. Explain squirrel cage rotor types and designs (EEMAC).
25. Define full load torque, starting torque, breakdown torque and pull-up torque.

26. Determine the effect of changing rotor resistance on starting torque and starting current.
27. Determine the effect of changing rotor resistance on full load speed.
28. Explain how torque changes throughout the load and speed range of a rotor.
29. Explain the speed control of a wound rotor motor.
30. Describe the characteristics and relationships between torque, speed, voltage and horsepower of three phase induction motors.
31. Calculate torque, horsepower or speed for induction motors.
32. Describe the effect of loading on induction motors.
33. Determine the effects of reduced line voltage on an induction motor.

B. Principles of Electricity..... 24 Hours

Outcome: Understand the electrical characteristics of three-phase circuits.

1. State and demonstrate the connections and relationships between three phase wye (star) systems.
2. State and demonstrate the connections and relationships between three phase delta systems.
3. Compare voltages of three-phase wye and delta connected loads.
4. Compare currents of three-phase wye and delta connected loads.
5. Calculate voltage, current and power in three phase balanced systems.
6. Calculate voltage, current and power in three phase unbalanced systems.
7. Calculate power factor correction of three phase systems.
8. Measure power using a three-phase wattmeter.
9. Calculate power using the three wattmeter method.

SECTION TWO:..... MOTOR REWINDING.....110 HOURS

A. Motor Winding Theory ..... 60 Hours

Outcome: Understand the components, design and connections of three-phase motors.

1. Identify various motor winding failures.
2. Describe core loss testing.
3. Describe appropriate stripping procedures.
4. Describe appropriate data recording.
5. Describe insulation characteristics including:
   a) phase insulation
   b) slot insulation
   c) separators
   d) sleeving
6. Describe temperature classifications of insulation materials.
7. Describe classifications of magnet wire.
8. Describe classifications of lead wire.
9. Describe rewinding using the lap method.
10. Describe rewinding using the concentric method.

11. Describe series and parallel star (dual voltage) connection method.
12. Describe series and parallel delta (dual voltage) connection method.
13. Describe two, four, six and eight pole connection method.
14. Describe one and four connection method.
15. Describe one and seven connection method.
16. Explain coil pitch.
17. Explain coil span.
18. Explain chording, coil distribution and the reasons for doing so.
19. Determine pole-phase groups for odd or even grouping.
20. Explain chord factor and distribution factor as well as their effects on the overall motor characteristics.
21. Explain the skip group method of connecting.
22. Explain the reversed "B" phase method of connecting.
23. Draw radial, block and line connection diagrams.
24. Describe connection schematic diagrams.
25. Explain and demonstrate turns per coil and slot fill.
26. Describe the construction of form-wound coils.
27. Describe the construction of mush/random-wound coils.
28. Describe different rewinding and connecting methods to achieve multi-speed operation using two-windings including:
    a) possible speed combinations
    b) winding pitch
    c) coil grouping
    d) wire sizes
    e) connections
    f) insulation requirements
29. Describe different rewinding and connecting methods to achieve multi-speed operation using single-winding consequent poles including:
    a) possible speed combinations
    b) winding pitch
    c) coil grouping
    d) wire sizes
    e) connections
    f) insulation requirements
30. Calculate voltage and frequency changes by reconnection or rewind.
31. Calculate wire size and turns required to produce similar horsepower and speed characteristics when voltage change is being carried out.
32. Determine if a motor is capable of being redesigned for a change of speed.
33. Determine reconnection or winding changes required to change speed. (e.g. 1800 to 1200 RPM) including:
    a) grouping of coils
    b) connections
    c) wire size
    d) number of turns per coils
    e) hp relationship
34. Convert lap windings to concentric windings and vice versa.
35. Explain the difference between standard windings verses inverter duty windings.

B. Motors Winding Lab ..... **40 Hours**

Outcome: Demonstrate the correct procedure for rewinding a three-phase motor.

1. Identify appropriate class of insulation.
2. Demonstrate appropriate stripping procedures.
3. Demonstrate the correct method of recording winding data.
4. Manufacture full set of mush/random coils for a three-phase motor.
5. Size and install slot insulation.
6. Install full set of coils including required insulation.
7. Determine motor lead size.
8. Connect stator windings and attach leads.
9. Bind and secure windings.
10. Test rewound motor by acceptable methods.

C. Rotors Lab ..... **10 Hours**

Outcome: Understand rotor testing and causes of failures.

1. Diagnose rotor faults including techniques of troubleshooting using growlers and single-phase excitation.
2. Determine rotor condition by full load and no load testing.
3. Explain the methods of repairing rotors.

SECTION THREE: ..... TRANSFORMERS ..... 36 HOURS

A. Theory of Operation ..... **14 Hours**

Outcome: Understand the types and principles of operation of transformers.

1. Describe the different types of transformers including:
   a) power
   b) distribution
   c) instrument
   d) isolating
2. Describe the basic components of a transformer.
3. Explain the nameplate information of a transformer.
4. List the purposes of a transformer.
5. Identify primary and secondary windings of a transformer.
6. Differentiate between a step-up and a step-down transformer.
7. Explain the standard terminal and winding identification.
8. Describe transformer action.
9. Describe the operation of a transformer as load is added.
10. Determine the losses of a transformer.
11. Determine the efficiency of operation.
12. State how transformers are rated and sized.

13. Describe and solve problems involving transformer voltage, turns and current ratios.
14. Explain the reason why transformers are rated in voltage and volt-amperes.
15. Differentiate between subtractive and additive polarity.
16. Describe the methods of cooling transformers.
17. Identify liquids used for cooling transformers.
18. Describe the function of current and potential instrument transformers.
19. Calculate wattmeter readings using instrument transformers.
20. Explain maintenance and oil testing procedures.
21. Describe proper handling and disposal of transformer coolants.

B. Connections for Single Phase and Three Phase Transformers ..... 22 Hours

Outcome: Demonstrate the ability to connect transformers for various applications.

1. Demonstrate ability to determine polarity.
2. Demonstrate identification of leads.
3. Demonstrate transformer connections for single-phase applications.
4. Demonstrate transformer connections for three-phase applications.
5. Describe the operation of a three-phase transformer.
6. Describe and demonstrate connections for autotransformers.
7. Identify faults in transformer connections.

SECTION FOUR: ..... SAFETY AND REGULATIONS ..... 2 HOURS

A. Canadian Electrical Code Part 1 ..... 2 Hours

Outcome: Understand why and how the Canadian Electrical Code (CEC) Part I is used to provide minimum standards as they apply in the trade.

1. Calculate the size of conductors for external connection to motors.
2. Determine lead wire insulation classification.

FOURTH PERIOD TECHNICAL TRAINING
ELECTRICAL MOTOR SYSTEMS TECHNICIAN TRADE
COURSE OUTLINE

UPON SUCCESSFUL COMPLETION OF THIS PROGRAM THE APPRENTICE SHOULD BE ABLE TO PERFORM THE FOLLOWING OUTCOMES AND OBJECTIVES.

SECTION ONE: ..... TRADE APPLICATIONS ..... 50 HOURS

A. Explosion-Proof Motors ..... 12 Hours

Outcome: Demonstrate techniques required to rebuild explosion proof motors and locate applicable standards.

1. Identify an explosion proof motor.
2. Record the documentation necessary for re-certification of an explosion proof motor.
3. Demonstrate the techniques of handling explosion proof motors.
4. Demonstrate the correct method of dismantling explosion proof motors.
5. Explain stripping and rewinding techniques of explosion proof motors.
6. Explain and demonstrate the correct method of reassembling explosion proof motors.
7. Demonstrate an ability to locate and interpret sections of the CSA standards, namely:
   a) C22.2 #30
   b) C22.2 #145
8. Demonstrate an ability to locate and interpret applicable sections of the CEC.

B. DC Armatures ..... 6 Hours

Outcome: Describe the process of troubleshooting and maintaining DC armatures.

1. Describe commutator maintenance including cleaning, machining, hand stoning, under cutting, side cleaning, bevelling and polishing.
2. Identify equipment fault by commutator appearance.
3. Describe the testing and winding procedures of DC armatures.
4. Describe coil types and connections of DC armatures.
5. Describe armature banding methods and materials of DC armatures.
6. Explain methods of temporary repairs of DC armatures.
7. Explain the process of adjusting brush holders and seating brushes.
8. Describe leading, trailing and radial brush mountings.
9. Select proper brushes including:
   a) size of brushes
   b) brush grades

C. Phase Converters ..... 8 Hours

Outcome: Describe the various types and operation of phase converters.

1. Explain the principle of operation and connection of phase converters.

2. Describe the various types of phase converters.
3. Demonstrate the connection of a 12 lead motor for phase converter operation.

D. Troubleshooting Rotating Electrical Equipment ..... 4 Hours

Outcome: Demonstrate the ability to identify faults in rotating electric equipment.

1. Explain the results of rotating electric equipment operating under low voltage condition.
2. Explain the results of rotating electric equipment operating under high voltage condition.
3. Explain the results of rotating electric equipment operating under over loaded condition.
4. Explain the results of rotating electric equipment operating under blocked ventilation condition.
5. Explain the results of rotating electric equipment operating under single phasing condition.

E. Vibration Analysis ..... 12 Hours

Outcome: Explain causes of vibration and demonstrate methods of identifying machine vibration.

1. Explain vibration using the associated terminology.
2. Describe methods of measuring vibration.
3. Describe how strobe lights are used to measure phase angles and check shaft rpm.
4. Describe machine signature and its importance in vibration analysis.
5. Explain the causes of vibration in rotating equipment.
6. Explain basic vibration analysis.
7. Demonstrate the use of a vibration analyzer.
8. Demonstrate the ability to interpret vibration signatures.
9. Describe solutions to vibration problems.

F. Balancing ..... 8 Hours

Outcome: Explain and demonstrate balancing methods.

1. Describe causes of imbalance.
2. Describe the types of imbalance.
3. Define imbalance and balancing.
4. Explain imbalance correction methods and considerations.
5. Explain the single plane vector method of balancing.
6. Explain the two-plane vector method of balancing.
7. Demonstrate the ability to balance a rotating piece of equipment using the single plane vector method.

SECTION TWO: ..... THREE PHASE MOTOR STARTERS AND CONTROLLERS ..... 50 HOURS

A. Starters ..... 30 Hours

Outcome: Describe the various types and principles of operation of motor starters and demonstrate proper connection methods.

1. Describe the effects on induction motors when started by reduced voltage means.
2. Describe the operation of manual across the line starters.
3. Describe the operation of across the line magnetic starters.
4. Describe the operation of compensator (autotransformer) starters.
5. Describe the operation of primary resistant starters.
6. Describe the operation of part winding starters.
7. Describe the operation of wye-delta starters.
8. Explain the operation of electronic soft-starter.
9. Explain the operation of I.E.C. and NEMA overload devices.
10. Explain the principles of motor designs used in various reduced voltage starting methods.
11. Demonstrate the ability to connect the various types of motor starters.

B. Controllers ..... 10 Hours

Outcome: Describe the various controllers for wound rotor and multi-speed motors and demonstrate connections for both.

1. Describe and explain the principle of operation of controllers and resistor banks for wound rotor motors.
2. Demonstrate the connection of controllers and resistor banks for wound rotor motors.
3. Describe and explain the principle of operation of multi-speed motor controllers.
4. Demonstrate the connection of multi-speed motor controllers.

C. Adjustable Speed Drives ..... 10 Hours

Outcome: Describe the various types and applications of adjustable speed drive systems and motors.

1. Describe the different types and advantages of adjustable speed drive systems and their applications.
2. Describe the operation of variable frequency drives.
3. Describe the operation of SCR DC motor drives.
4. Identify and select the proper motor type for different applications.
5. Demonstrate capabilities to connect, program and troubleshoot adjustable speed drives.

SECTION THREE: ..... SYNCHRONOUS MACHINES ..... 44 HOURS

A. Motors ..... 22 Hours

Outcome: Describe the principles of operation and methods of control for synchronous motors.

1. Name the parts of a synchronous motor.

2. List and explain the information found on the motor's nameplate.
3. Describe the applications of synchronous motors.
4. Explain the principle of operation of a synchronous motor.
5. Describe the methods of starting synchronous motors.
6. Explain the effects on synchronous motors with load changes.
7. Explain the effects on synchronous motors with changes to field excitation.
8. Describe the operation of synchronous condensers.
9. Demonstrate the connection of synchronous motors and record the electrical measurements during operation.

B. Alternators ..... 22 Hours

Outcome: Describe the principles of operation and methods of control for synchronous alternators.

1. Name the parts of a synchronous alternator.
2. List and explain the information found on the nameplate of an alternator.
3. Describe the applications of synchronous alternators.
4. Explain the principle of operation of synchronous alternators.
5. Describe the various types of field excitation.
6. Explain the effects on synchronous alternators with load changes.
7. Describe and demonstrate paralleling and parallel operation of synchronous alternators.
8. Explain voltage regulation and factors affecting it.
9. Demonstrate the effects of different load types on synchronous alternator operation.
10. Describe common problems and troubleshooting methods for synchronous alternators.

SECTION FOUR: .....ELECTRONICS / DIODES / RECTIFIERS ..... 40 HOURS

A. Electrical Properties and Measuring Instruments ..... 18 Hours

Outcome: Explain the characteristics of fundamental electronic circuit components.
Demonstrate the use of measuring instruments in fundamental electronic circuits.

1. Explain the different ways of defining voltage and current values.
2. Explain the electrical properties and ratings of resistors.
3. Explain the electrical properties and ratings of capacitors.
4. Explain the electrical properties and ratings of inductors.
5. Use test equipment to measure the electrical characteristics of component and circuit properties.

B. Diodes and Rectifier Circuits ..... 12 Hours

Outcome: Describe the principles of operation and the applications of diodes in rectifier circuits.

1. Explain the operating characteristics of diodes.
2. Describe the principles of operation of single-phase rectifiers.
3. Describe the principles of operation of three-phase rectifiers.

4. Demonstrate the connection of diodes as used in rectifier circuits.
5. Describe and demonstrate the effects of adding filters to a rectifier circuit.

C. Applications of Diodes and Rectifiers ..... 10 Hours

Outcome: Identify, test and replace the rectifier components in a battery charger and welder.

1. Select replacement rectifier components including diodes, heat sinks and filter capacitors from manufacturer's specification sheets.
2. Describe the operation of and troubleshoot the rectifier stage of a battery charger.
3. Describe the operation of and troubleshoot the rectifier stage of a welder.
4. Describe the practical aspects and typical applications of diodes.

SECTION FIVE: ..... ELECTRONICS / POWER / SWITCHING ..... 32 HOURS

A. Transistors and Photo Devices ..... 12 Hours

Outcome: Identify, test and state applications for bipolar junction transistors, insulated gate bipolar transistors and various photo devices.

1. Describe the principles of operation and applications of the bipolar junction transistor.
2. Describe the principle of operation and applications of the insulated gate bipolar junction transistor.
3. Describe the principle of operation and applications of various photoelectronic devices.
4. Demonstrate the ability to test the bipolar junction transistor.
5. Demonstrate the connection of a bipolar junction transistor as a current control device.

B. Thyristors ..... 10 Hours

Outcome: Describe the principles of operation and typical applications of common thyristor devices.

1. Describe the principle of operation and application of an SCR (silicon controlled rectifier).
2. Describe the principle of operation and application of an SCR firing circuit.
3. Describe the principle of operation and application of a Triac.
4. Analyze a circuit application using a Triac to control a resistive lighting load.

C. Practical Applications of Thyristor Circuits ..... 10 Hours

Outcome: Analyze the operation of and troubleshoot the thyristor stages of typical industrial applications.

1. Connect and troubleshoot a circuit that uses an SCR to control a DC motor from a single-phase supply.
2. Troubleshoot a circuit that includes an SCR used to control a DC motor from a three-phase supply.
3. Troubleshoot a circuit that includes an SCR used in a battery charger circuit.
4. Connect and troubleshoot a circuit of a Triac used in motor control circuits.

SECTION SIX: ..... ELECTRONICS / APPLICATIONS ..... 4 HOURS

A. Voltage Regulators ..... 4 Hours

Outcome: ***Describe how voltage regulators control the output or terminal voltage of a generator while operating at varying loads.***

1. Describe the operation of a shunt regulator.
2. Describe the operation of direct current machine voltage regulators.
3. Describe the operation of a commercial alternator voltage regulator.

SECTION SEVEN: ..... ELECTRIC WELDING EQUIPMENT ..... 4 HOURS

A. Trouble Shooting Electric Welders ..... 4 Hours

Outcome: ***Describe the principles of operation of electric welders. Demonstrate the ability to troubleshoot electric welders.***

1. Describe the primary components of an electric welder.
2. Describe the principle of operations of transformer type electric welders.
3. Describe the principle of operations of rotating electric welders.
4. Demonstrate the ability to troubleshoot and maintain electric welding equipment.

SECTION EIGHT: ..... PROGRAMMABLE LOGIC CONTROLLERS ..... 16 HOURS

A. Theory of Operation ..... 4 Hours

Outcome: ***Describe the fundamental operation and programming of a Programmable Logic Controller (PLC).***

1. Describe the function and application of the PLC and components.
2. Describe the function of the input and output (I/O) modules of a PLC system.
3. Describe the basic programming methods used in PLC's.
4. Describe the technique of addressing discrete I/O field devices.
5. Explain how to program a stop-start control circuit from a ladder diagram.
6. Explain the methods of disabling and forcing.
7. Describe the method of troubleshooting a circuit.

B. Practical Applications ..... 12 Hours

Outcome: ***Demonstrate the ability to connect and program a Programmable Logic Controller (PLC).***

1. Program a dual stop-start station.
2. Program a jogging circuit.
3. Program forward-reverse operation.
4. Program a hand-off-auto switch.
5. Program a P.L.C. timer.

6. Explain the function of a holding register.
7. Explain the function of a retentative timer.
8. Explain the function of a Time Delay on Energization (T.D.E) (on delay) timer.
9. Explain the function of a Time Delay De-energization (T.D.D) (off delay) timer.
10. Program a P.L.C. counter.

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